Indicators of a Flowless Construction process

Jørgensen, Kirsten; Bonke, Sten

Published in:
Conference proceedings. Joint CIB International Symposium of W055, W065, W089, W118, TG76, TG78, TG81 and TG84

Publication date:
2012

Document Version
Publisher's PDF, also known as Version of record

Indicators of a Flawless Construction Process

Kirsten Jørgensen, kirj@dtu.dk
DTU Management Engineering, The Technical University of Denmark
Sten Bonke, sbon@dtu.dk
DTU Management Engineering, The Technical University of Denmark

Abstract

This paper is reviewing an ongoing research project which has two central aims. Firstly, to identify and analyse indicators of central importance to a successful construction process in the perspective of handing-over flawless buildings to clients. Secondly, from this knowledge, to deduce methods of best-practice in order to reduce the level of defects in construction projects.

The research draws upon statistics from The Benchmark Centre for the Danish Construction Sector (BEC). BEC has been collecting data on the number and character of defects (legally defined) in connection with buildings at hand-over to clients since 2004. Furthermore, research data is based on an electronic questionnaire filled in by clients and contractors as a retrospective analysis of the management conditions in construction projects resulting in either none or many defects at hand-over to the client. A total of 130 responded to the questionnaire.

Processing of data and information from questionnaires has been carried out using different statistical and analytical methods. Focus has been on the number and graduation of seriousness of defects, on type of tender and organization of the construction process, on the type of client and on budgetary issues. The qualitative analysis focused on management of budget, time, quality, collaboration and coordination, competences and skills, safety and risk, and on the complexity of the construction projects.

The results of the analysis are showing statistically significant differences for those construction processes characterized by few or no defects compared to those with many serious defects. The planning of budgetary conditions, time schedules, and an early and continuous defects control proved to have the most significant influence on the final results related to defects in the building at hand-over to the client. Furthermore, also quality control, the collaboration between parties, skills and safety initiatives are influencing factors in the analysis of results.

Keywords: Construction Defects, Flawless Construction, Management, The Delivery Process

1. Introduction

This paper presents a number of results from an ongoing research into construction processes focusing on factors influencing the occurrence of defects at hand-over of completed buildings to the client.The research project comprises of an analysis of two sets of data on construction. One originates from The Benchmark Centre for the Danish Construction Sector (BEC-data). It contains data on evaluations of completed buildings throughout the period 2007-10. The other data set represents a questionnaire survey (SPSK data) among contractors and clients being asked specifically on the conditions characterizing the construction of the buildings which had been subject to BEC evaluations.The purpose of analyzing these data is to investigate whether different characteristics can be identified when comparing buildings with many defects at hand-over versus buildings with few such. And if so to specify the nature of these different characteristics on construction project and contract level.

2. Theory

Building research within this field shows many different causes of defects and general discrepancies which can be localized throughout the whole value chain of construction project. Some references have sought to categorize some of the most important types of causes in relation to both actors and processes (Jørgensen 2009). Explanations of causes related to the involved actors' attitudes and actions are characterized by 1: lack of communication and coordination (Josephson 1994, Apelgren et al. 2005, Nielsen et al. 2004), 2: lack of knowledge and experience (Josephson 1994, Nielsen et al. 2004), and 3: engagement, stress and time pressure (Josephson 1994, Nielsen et al. 2004). Other sources, however, emphasize problems with defective project information, defects in building products, poor planning, and poor execution of work (Nielsen 2004). Explanations of causes related to building processes include deficiencies in the client's project brief, when defining the concept, the quality level, and functional demands for the project. Thus the client's strategy in relation to quality level, and the relationship between the level of ambition and the resources for technically ensuring the construction quality are some of the critical elements typically involved (Henriksen & Hansen 2006). But also deficiencies and errors in the project design - and defects in deliverances from supplies, deficient planning of execution of the work, contractors' poor management and organization of work, and scanty management of delays and operations' flow are perpetually referred to in literature (Josephson 1994, Nielsen et al. 2004, Apelgren et al. 2005). Case stories on building processes are outlining a rather clear picture of the complexity of construction projects, thus indicating how seemingly insignificant factors and different understanding of situations can often lead to unfortunate and undesirable consequences (Kreiner 2005, Jørgensen 2009). It has therefore been considered appropriate in the theory review below to examine these areas of problems within the construction process which have been selected as crucial by different researchers. Subsequently, the analytical aim of this research project has been to establish an empirical outset for identifying such problems as objective indicators on the outcome of production processes as measured by defects. For instance, research shows that an important prerequisite for being able to estimate costs in the initial phases of a construction projects is related to knowledge on potential and possible solutions, on the cost of these and on how fast they can be realized (Winch 2010). An ongoing and accurate cost management in

construction projects is consequently essential for a successful result (Chapman et al. 2010). It is only too well known that budget and time schedules are playing a central role in building processes, where insufficient financial resources and management lead to the problems as listed above, while insufficient time frames results in forced building operations which in particular are causing pressure and poor workmanship during the last phases of the process. Further relevant factors regarding economy are the use of incentives and bonuses in order to reward firms or actors for efficient deliveries and work. Experiences with open project economy with firms sharing their internal accounts have also proved to create greater trust between the parties involved in the project. This principle is for example applied in partnering projects as a method to improve the quality of design information and decision making. Some of the traditional problems related to flaws in the building process are 1: that the client often chooses to aim at the lowest price; 2: that the client's requirements on the construction project are not sufficiently precise; 3: that there is little focus on the business aspects of the case; and 4: that competition at tender often leads to underbidding. Such issues are resulting in defective project planning and implementation, poor buildability, inexact specifications, and resistance toward using experts and towards finding weaknesses and areas of risk. If these are furthermore amplified by lack of planning and management skills, then surely the project success will fail to appear (Winch 2010). However, a clear division of responsibilities can minimize the risk and effect of unexpected occurrences (Szentes 2010) - and also help the actors to optimizing their own main tasks. It is therefore important that the project has a well-functioning project management group with clear goals and agendas (Szentes 2010). Exactly because construction projects have many different stakeholders and actors, increasing difficulties will occur if in particular the management and organization are not robust towards handling such problems as tortuous paths of communication, lack of mutual understanding, unpredictable building site conditions, opaque frameworks for the quality of the work done, and incomplete deliveries by suppliers (Loushine 2006). Therefore, good reasons to focus on coordination, communication and cooperation remain crucial. Deficient design and integration of quality in the building process is inversely creating a general lack of focus on quality and customer value, poor contracts, and absent understanding of the general difficulties related to carrying out construction projects (Leong & Tilley 2008). This points to the question forms of collaboration and culture, also including the team awareness of the quality expected by the client. The project manager's style of leadership as concerns commitment and involvement are central factors (Yang et al. 2010, Misumi 1985). So is his ability to develop coherence and realistic plans (Chua et al. 1999, Winch 2010), since well-functioning planning practices are of central importance to realizing the construction project. However, because not all detailed aspects of a construction project can ever be planned, also the manager's capability in dynamic problem solving is crucial (Winch 2010, Thuesen 2006). It is well known that a central element in planning practices implies the use of concepts, methods and tools which can optimize the project's overall design aspects in the perspective of balancing quality, economy and time. Having transformed such main decisions into specific plans (budget, schedules, QC etc.), the ongoing management and follow-up upon these plans is essential (Winch 2010, Szentes 2010). This entails continued monitoring of the project's current status in order to identify discrepancies in relation to planned performance (Szentes 2010). During this process the management's attention towards quality issues will of course be depending of precisely the explicitly – but also implicitly - expressed requirements on the level of quality and quality control, time and resource planning, monitoring and control of deliveries etc. (Jørgensen 2009). Thus the management style and behavior is due to vary from project to project in accordance with influencing factors of

external nature. As mentioned collaborative processes are of central importance to the output of activities in construction (Winch 2010, Szentes 2010). An important aspect of the collaborative effort is the ability of the project organisation to formulate common goals and to continuously follow up upon these, as seen for example in partnering projects. A long list of means and tools can be applied to raise the level of trust and collaborative atmosphere, like team-building, open accounts, conflict management, celebration of achieved project successes etc. (Szentes 2010). Organizational access to appropriate competences is important for the project's success. Lacking competences at designers as well as at contractors are due to be causing defects in construction projects (BEC 2008). Also project management competences in particular are seen to be a critical success factor (Szentes 2010). These include the capability of facilitating open communication and collaboration in the process of formulating common goals, as mentioned above. So one of the central, ad often neglected challenges in resource allocation and planning is the ability to attract and maintain a qualified personnel and workforce during the project phases (Chapman et al. 2010). As aspects of qualifications/competences experience and skills are of central importance in construction. Experience is embedded in individuals (Thuesen 2006), and it is necessary to differentiate between for instance general experience, experience from similar projects, and mutual knowledge in social relations. Thus competences and experiences are equally important in choosing partners for a project (Hardeman & Vlist 2010) - but unfortunately such parameters are rarely given priority when confronted with the lowest price. Finally, new technology and innovation have great significance in project design and execution (Wadugodapitiya et al. 2010, Chapman et al. 2010). In the perspective of management innovation, the working climate is heavily influencing performance (Wadugodapitiya et al. 2010), including such factors as employee satisfaction, working hours and stress conditions, absence due to illness, and the overall working environment. These issues have direct and indirect implications on the quality culture in projects. A relevant source of knowledge and inspiration regarding the effect of quality culture is represented in the databases of the Construction Industry Institute (CII), Texas University which is performing continued benchmarking surveys on large American construction projects. According to CII, beneficial quality culture can be indentified from the use of planning and management concepts and tools such as lean construction, partnering, TQM, SCM, team building, collaboration, quality control systems and requirements, and safety work. CII also finds that the characteristics of quality culture can be associated with competences which point to a quality determined choice of partners, whether foreign labor is used, and for instance such basic conditions as accessibility, waste management and clean up standards. Knowledge sharing, trust and involvement of craftsmen also show up to be crucial. The numerous perspectives and sources reviewed above will be addressed thematically in the analytical approach of the research project. Particularly, they will be framed into the empirical part of the research.

3. Research methods

The Benchmark Centre for the Danish Construction Sector (BEC) is a business foundation established by a broad circle of actors from the construction sector in order to promote quality and efficiency. The Center's function is to collect and organize information and evaluations from the parties involved in construction projects. The collected data is used to calculate key performance indicators. The type of defects, deficiencies and failures registered in BEC are defined as legal events, i.e. discrepancies

registered by the client by hand-over, thus expressing some sort of lacking conformance between what has been delivered and what was agreed upon by the customer and the supplier (the client and the contractor). BEC calculates defects as the number of concrete defects and not as technical types of defects. Defects are classified into three categories:

- A0, cosmetic defects, i.e. defects with no or insignificant technical consequence to construction.
- A1, less serious defects, i.e. defects with little technical construction significance; defects without influence on the construction - or affecting the function of parts of the construction project.
- A2, serious or critical defects, i.e. defects with some or great technical construction significance; defects that affect the construction or the function of parts of the construction project.

An extract from BEC's data base on reported defects per DKK 1 mill. contracted project budget is showing an average occurrence of number of defects distributed among the above three categories of seriousness in the relationship 1:5:50. This relationship is then applied for a statistical weighting of defects in the individual construction project, thus making it possible to sum up a numerical value suitable for comparing across projects, as the value 15 represents the average construction project (Jørgensen 2010). On this basis the evaluated construction projects have been shaped into three 'quality groups':

- Quality group A contains the construction projects delivered with none or few cosmetic defects
- Quality group B contains the projects delivered with typical defects on average level
- Quality group C contains the projects delivered with many and serious defects

	Quality group		
329 construction projects	A	B	C
Cosmetic failure	0,97	6,45	14,6
Typical failure	0,06	0,98	5,96
Critical failure	0	0,04	0,49

Figure 1: Illustrates the distribution of the 329 construction projects, evaluated by BEC, located in three quality groups and indicating the three types of defects and their degree of seriousness. The figure shows the average number of defects per 1 mill. contract sum in the construction projects located within each of the three quality groups.

The BEC dataset comprises of 329 construction projects and 621 contracts. 51 % of these are located in quality group A; 34 % in quality group B and 15 % in quality group C. Further to these data a questionnaire of 90 questions was then composed, covering the themes shown in table 1.

The questionnaires were deployed to clients as well as contractors – and responses were subsequently linked to information already present in the BEC data set. Responses were collected from 67 clients and 130 contractors. Later it showed most relevant to analyze closer responses from contractors. The representatively of responses from contractors in the three quality groups is 56% in A, 29% in B, and 15% in C. This distribution is close to average (as indicated above). The actual analysis was divided into three. Initially a univariate analysis of all information in the BEC data set plus responses from the questionnaire was carried out – focusing on statistical disparities between the three quality groups. Then on the basis of this analysis the 90 questions were divided into themes, broadly corresponding to table 1 thematically, and a new univariate analysis was carried out in order to identify a distinction between respondents with a very positive attitude in answering, against those answering negatively to the generally positively expressed questions. The third type of analysis is then consisting of an exposure of links using correlation and multivariate methods in order to create profiles of the 'good and the bad' respectively.

Table 1:Themes for the questionnaire

Economy	BEC´s data on economy are supplemented with: • Budgetary Planning • Cost management • Consequences of budget • Incentives and bonuses
Construction schedules	BEC´s data on construction schedules and deadlines etc. are supplemented with: • Construction schedule requirements • Time scheduling and time consumption • Time consumption for project phases
Value and priorities	• Project priorities • Basis for selecting partners
Quality	• Planning quality • Producing quality • Quality result
Competences	• Management skills • Survey of the parties' skills
Collaboration	• Collaboration climate • Collaboration forms and agreements • Involvement across the parties • Methods for strengthening collaboration
Coordination and planning	• Managing project changes • Meetings and meeting structure • Planning methods • Production process
Working environment	• Safety work implementation • Safety conditions on the building site
Risks, complexity and innovation	• Construction project complexity • Innovative methods • Important risks

4. Results

The analyses have been carried out for the 130 contractors exclusively who have responded to the questionnaire. Responses from the 67 clients have not been made subject to analytical efforts, the argument being their limited number and a very small differentiation with a general attitude in the most positive end of the scale. This may indicate that either only the most satisfied clients responded – or alternatively: clients did not find themselves capable of responding to questions on a detailed level about concrete conditions and problems in the construction processes. However, BEC´s own measures of clients' satisfaction shows a clear correlation between high versus less high satisfaction with the construction process in relation to the range and seriousness of defects when comparing quality groups A and C. The analyses of contractors' responses are showing generally largest differences between quality groups A and C, while values for quality group B are fluctuating between the two extremities. Therefore, a major analytical effort will be concentrating on the differences between quality groups A and C. Thus the univariate analytical approach is indicating the following two issues to be representing the strongest differences of statistical significance between quality groups A and C:

1. Cost management
2. Early and continuous management of defects

There is much evidence that these two issues have major influence on the occurrence of defects at hand over. Looking at the specific questions the following questions are showing statistical significance when relating quality group A and C:

- Cost management:
  - The budgetary framework has an influence on construction quality, particularly when budget and demands on quality are conforming.
  - There is good conformance between the result delivered and the construction costs.
  - It is of importance that clients are capable of setting objectives for the overalll cost management.
  - It is of importance that designers are capable of making reasonable design solutions in relation to budget and resources.
- Schedule management:
  - The time schedule and the demands on quality level showed to be in good conformance.
- Defect management:
  - Considering handling of defects this is typically dealt with during the process of construction, however, more often in quality group A the construction is specifically reviewed for defects and these are rectified before hand over.
- Execution of quality management:
  - Contractors in quality group A are more critical towards the quality of project specifications, the contractual basis and the brief as concerns quality management than contractors in quality group C. This is supported by the fact that group A contractors more often carry out quality review on project specifications prior to construction, just as clients in group A have a more explicit notion of contractors'

respect towards their demands on quality (however this statement cannot be demonstrated with statistical significance.
    - Furthermore, quality group A responds more positively to questions concerning preparation of adequate plans for supervision and control, appropriate handling of interfaces between trades – and reasonable control of own work (again, statistical significance has not been achieved).
- Management skills:
    - Evaluations of competences are generally scoring high. However, group A actors' capabilities are on a higher level than those of group C. (statistical significance has not been achieved).
- Collaboration in relation to cost, time and quality:
    - Quality group A is giving higher priority to balancing costs, time schedules and plans for quality control as collaborative, open and joint solutions (statistical significance has not been achieved).
- Health and safety management:
    - Considering management of the working environment the responses from quality group A score higher compared to group C, in particular concerning planning of safety during the design and production stage, and also concerning waste disposal, neatness and tidily conditions on site.

Furthermore, analyses have been focusing on forms of contracts in relation to project size and total costs. Contracts have been divided into D&B contracts, main contracts and trade contracts. Responses differentiate most when comparing D&B projects with trade contract projects. Generally, responses from the first type of contracts score higher than those related to the other types. In 58 out of 65 questions D&B projects score higher than trade contract projects, and in 36 of these questions the difference is statistically significant. When looking at differences between the quality groups A and C in relation to contractual forms, a larger variation can be observed within D&B projects while the variety is less pronounced within trade contract projects. Differences between quality groups A and C in D&B projects are statistically significant as concerns these questionnaire themes:

- Cost management
- Scheduling
- Early and continuous management of defects

Furthermore, a certain difference can be observed concerning the questionnaire themes 'Budget consequences', 'Time frames for design and review', 'Management skills', 'Workforce skills', 'Collaboration in costing, scheduling and quality', and in 'Mutual acquaintance'. Differences between quality groups A and C in trade contract projects are statistically significant as concerns these questionnaire themes:

- Managing the quality system
- Skills of construction workers

Responses to the other questionnaire themes are characterized by minor differences between quality groups A and C. Moreover, D&B projects stand out remarkably because of using new concepts of

collaboration and management, more involving of production trades in the design process, larger planning efforts in relation to meetings, supplies, processes etc, and because of implementing 'safety-audit sites' and safety instructions. Thus D&B projects for instance apply methods associated with partnering and lean construction. In trade contract projects contractors have more difficulties in planning and managing costs and schedules; only to a lesser extent they carry out continuing defect reviews and they have difficulties in creating a good working climate. As earlier mentioned BEC is collecting information on construction projects on the overall level as well as on the individual contract level, relating to the total project budget and to the budget of the single contracts. In this research the size of projects has been divided into three budget groups: below DKK 5 mill., between DKK 5-25 mill., and larger than DKK 25 mill. Looking at the project budget statistically significant differences appear between quality group A and C, particularly for projects budgets beyond DKK 25 mill. Concerning small projects below DKK 5 mill. the results are showing statistically significant differences in contracts in quality group A and in C in relation to the following questionnaire statements:

- The client was qualified at determining the overall planning of costs and resources.
- The design team was qualified at making reasonable solutions in relation to costs and resources.
- There was no need for the client to withhold payment rates at hand over.
- The client's demands on the craftsman quality appeared clearly from the project specifications/brief.
- The client's demands on quality management in the construction process appeared clearly from the contractual set up.
- The client's quality demands were regarded during production.
- The contractor's own quality control was expedient
- The contractor knew suppliers/the other contractors from previous projects.
- The solutions to complex construction areas were well managed (applying for instance lists of obstacles)
- The construction process was well managed (applying for instance PPC (Percent Planned Completed) measuring)
- Social events, beneficial for collaboration, were held.

For large construction projects (above 25 mill.) the results demonstrate statistical significant differences between contracts in quality group A and C within the following questionnaire themes:

- There was a good conformance between the delivered result and the construction costs.
- Openness between partners on economy issues was experienced (like in Partnering).
- There was no need for the client to withhold payment rates at hand over.
- The contractor felt no need to issue additional charges during the project.
- The time schedule and the demands on quality level in the project was in good conformance.
- Sufficient time for reviewing the project for securing of constructability and craftsman quality was av ailable.
- The contractor carried out defects review and rectification before hand over to the client.
- The contractor carried out a defects review together with the client at pre-hand over, and had defects rectified before final hand over.

- The client's demands on quality were regarded during production.
- The contractor assumes the craftsmen to generally have had the appropriate craftsman skills for filling out the job requirements.
- The project managers of both client and D&B contractor showed commitment, involvement and supporting collaborative attitude towards the different parties.
- The project parties jointly determined the appropriate costs, schedules, targets and sub-targets
- During the design process appropriate attention was paid to safety issues.
- The high complexity of the project made high demands on the innovative capabilities of the constractor.
- Teambuilding events with a positive influence on collaboration were held.
- The contractor employed financial incentives in order to comply with budgetary frameworks.

By grouping the questions into 30 thematic groups, data demonstrate significant differences for the large construction projects in relation to the question groups on budgetary planning, implementation of early and continuous defects review, craftsmen's skills, and collaboration on prioritizing and solutions. For small projects, however, significant differences concern budgetary planning and cost consequences. In the multivariate analysis a profile was sought for in order to illustrate the way in which quality group A differentiate positively from quality group C. This applies to the following themes: 'Budgetary planning', 'Cost consequences', 'Time scheduling', 'Time for design/review/production', 'Planning of quality, 'Early and continuous defects review', 'Execution of quality management', 'Management skills', 'Craftmen's skills', 'Collaborative climate', 'Collaboration in relation to budget, time and quality', 'Mutual previous acquaintance', 'Safety management', Contractors' competences', 'Applied concepts of collaboration', 'Engaging partners', 'Initiatives on collaboration', 'Applied lean meetings' and 'Safety procedures'.

5. Findings

As expected the analysis is demonstrating a vast number of factors to be of importance to completing a building without defects. It may also be considered trivial that good budgetary planning and continuous defect review processes have a major impact on the achieving a successful result. More interesting maybe is the observation of differences between a.o. D&B contracts and trade contracts. The research is showing good as well as poor results in both cases – however, much also indicates that it is somewhat easier to achieve good results within D&B projects. Furthermore, the division of project size on the basis of budget sum is showing rather big differences in the performance conditions when comparing larger projects above DKK 25 mill. with smaller projects below DKK 5 mill. Large construction projects are analytically characteristic by applying new management concepts, and they appear to be more capable at planning and management, which again is proving important for handing over the building with none or few cosmetic defects. Accordingly, those large construction projects not capable of providing decent planning and management, also deliver projects with many defects of serious categories. It is looking differently for smaller construction projects where capabilities of applying different planning and management methods are more vague – and where other factors may have determining influence on whether the project is finalized with none or few defects. One hypothesis could point to the dependence on individual random competences,

because dedicated management resources are often only to a limited degree allocated in small projects.

6. Discussion

The empirical data sets of this research are solely representing construction projects which have been evaluated by BEC. These account for only a smaller share of the total number of projects carried out in Denmark. Furthermore the response ratio to the questionnaire part is as low as 22%. It may therefore be discussed whether data is representative for Danish construction in general. Questions have been addressed to both clients and project managers in charge on contracts, as these were both acting as contact persons in the BEC evaluations. But it may be questioned whether these actors were best suited to respond to the type of questions specifically focused on the construction process, collaboration and coordination etc. There are some indications pointing towards contractors as being better informed than clients to giving detailed and differentiated answers to questions. Certainly, the importance of new management concepts, new process developments, implementation of ICTs and new building materials etc. may be underexposed - for the reason alone being that projects included in the analytical research did not apply such means to any particular extent. Finally, it may be discussed if the number of defects at hand over is a true and fair indication to whether the construction project has been successful in delivering value to the client and customer? When BEC has chosen to evaluate the proportions of defects at hand over it was from the beginning mainly due to a government policy aiming at reducing the problem of defects. In addition to this defect data had the practical advantage as a benchmark because such data already exist in construction projects, meaning that no further administrative burdens had to be inflicted on construction clients and firms. In relation to this methodological reservation, however, also questions on how different types of defects should weight reciprocally in seriousness scaling – and whether the weighting applied in this research is appropriate – should be discussed. The obvious correlation between clients' measure of satisfaction, and the categorizing of contracts in quality group A, B and C is telling in favor of defects as an excellent indicator, in particular when and if they are given mutual weight. But this fact is to a high degree depending upon the criteria defined by the client for his construction project, and upon the client's expectations on the quality of the commissioned building. There might also be a tendency in evaluations of customer satisfaction (in parallel to evaluation of defects) to generate information more on the finishing stage and completion of the construction project than on the process as a whole. Thus, it is well known that customer satisfaction is easily influenced negatively when only minor problems occur at take-over – and still the whole process of procuring and delivery may have been in perfect order.

7. Conclusion

The research results which have been reviewed in this paper provide us with important information about circumstances and factors of central importance to the flawless construction process. However, the investigation does not include specific knowledge on how to actually carry out the activities of planning, management and organization which constitutes these circumstances.

In its continuation the aim of this research project is to complete a qualitative study on the approach and performance of prime project managers when managing construction processes, focusing a.o. on effective cost management, time scheduling, quality control, defects review and management of suppliers and subcontractors. Moreover, a second aim is to put specific focus on how to implement a positive quality culture in construction projects.

8. References

Apelgren S., Richter A., Kock C. (2005) *Snublesten i byggeriet*, BYG-DTU, Denmark.

BEC (2008) *Byggeriets produktivitet – en tværsnitsanalyse fra 2004-2007*, The Benchmark Centre for the Danish Construction Sector, Denmark.

Chapman R.E., Butry D.T., Huang A.L. (2010) *Measuring and Improveing US Construction Productivity Proceedings*, CIB2010 & CIB562.

Chua Kog and Loh (1999) *Critical Success Factors for Different Project Objectives*, Journal of Construction Engineering and Management, Volume 125, Issue 3, pp 142-150.

Hardeman S., Van der Vlist A. (2010) *Public Procurements´ Qualification Requirements: The case of Dutch Civil Work Procurements*, Proceedings CIB2010 & CIB766

Henriksen K.R., Hansen E.J. (2006) *Kvalitet og byggefejl*, SBI, Denmark.

Josephson P.E. (1994) *Orsaker till fel i byggandet*, Chalmers Universitet, Sweden.

Jørgensen K. (2009) *Failures and Defects in the Building Process – Applying the bow-tie Approach*, Proceeding CIB 2009.

Jørgensen K., Rasmussen G.M.G., Thuesen C. (2010) *Indicators for building process without final defects -Methodology and theoretical foundation*, 6th Nordic Conference on Construction Economics and Organisation, Proceedings, Aalborg University, Denmark.

Kreiner K. (2005) *Læringssvigt i byggeriet*, CBS, Denmark.

Leong M.S., Tilley P. A. (2008) *lean Strategy to Performance Measurement – Reducing Waste by Measuring "Next" costumer Needs*, Proceedings IGLC-16.

Loushine T.W., Hoonakker P.L.T., Carayon P., Smith M.J. (2006) *Quality and Safety Management in Construction*, Total Quality Management, vol 17, No 9 1171-1212.

Nielsen A.S., Kristensen E.L. (2002) *Lean Construction – En redegørelse for det amerikanske produktionskoncept*, Afgangsprojekt på Aalborg Universitet , Denmark.

Szentes H. (2010) *Success Factors in Large Construction Projects*, Proceedings CIB2010 CIB1419.

Thuesen C. (2006) *Anvendelse af den rette viden – et studie af byggeriets kulturelle organisering,* Byg-DTU, Denmark.

Wadugodapitiya R.R.M.M.K., Sandanayake Y.G., Thurairajah N. (2010) *Building Project Performance Evaluation Model,* Proceedings CIB2010 & CIB967

Winch G.M. (2010) *Managing Construction Projects,* second edition Wiley-Blackwell

Yang J., Liu A., Fellows R. (2010) *Team Morale and Leadership Styles of Project managers in China Construction Projects,* Proceedings CIB2010 & CIB779.